Chapter 1

Energy Efficiency and Conservation Guidelines

1. Introduction to Energy Efficiency and Conservation

Temburong development, anticipated to occur soon after the completion of the Temburong Bridge linking Temburong district to Bandar Seri Begawan (BSB), offers Bruneians an opportunity to incorporate energy sustainability in developing an ecotown. These guidelines intend to assist the Ministry of Energy (MOE), Brunei Darussalam, in formulating a plan and a guide incorporating energy efficiency and conservation (EEC) measures in Temburong ecotown development. These guidelines aim to establish EEC practice requirements, minimum building energy performance, and other review and assessment requirements of the EEC section of a development plan submission. Henceforth, these are referred to as EEC building design submission as part of the overall building development plan submission to develop the Temburong ecotown.

These guidelines provide guidance on best practices, methodology, and assessment regarding minimum energy performance and other EEC assessment requirements to achieve energy efficiency in commercial and public service buildings in Temburong district. These buildings are expected to become a major load demand centre for energy besides the transport sector. The Ministry of Development (MOD) approves building development applications. However, the building energy performance assessment is deemed a subset of the overall building development application. These guidelines were prepared for the responsible department in the MOE (expected to be the Sustainable Energy Department) to review and assess the design compliance according to the EEC assessment criteria provided, in addition to the existing building regulations in Brunei Darussalam. In case of any contradiction between the requirements of these guidelines and the current building regulations, the requirements of the latter shall take precedence.

As these guidelines focus on EEC technical guidance, the administrative procedures and the existing statutory requirements for the building plan submission, processing, compliance, and approval are not included. This aspect of the building plan submission and processing procedures will be addressed by the ministries and authorities concerned. Successful implementation of the EEC strategies and measures recommended in these guidelines will depend on whether the existing regulatory requirements are adequate or whether specific EEC regulations will be introduced because implementation on a voluntary basis will not be effective.

1.1. Definitions

a) Designated buildings

This guideline sets out the guidance on EEC building requirements for commercial and public service buildings. For definition purposes, this guideline shall apply to the following categories of buildings, which are defined as designated buildings:

1) All new building works involving a gross floor area of 2,000 m^2 or more[1]
2) Additions or extensions to existing buildings which involve increasing the gross floor area of the existing buildings by 2,000 m^2
3) Building works involving major retrofitting to existing buildings with a gross floor area of 2,000 m^2 or more
4) All buildings meeting any criteria listed in the above will be classified as designated buildings

b) Commercial buildings

Commercial buildings are non-residential buildings used for commercial purposes, which include mixed developments. Typical commercial buildings comprise offices, hotels, and malls.

c) Public service buildings

Public service buildings are government buildings, including public service offices, and institutional buildings, such as hospitals and universities.

d) Qualified person

A qualified person shall be a building professional who submits building plans to the MOD for approval following the statutory requirements.

1.2. Approval process of EEC building proposals

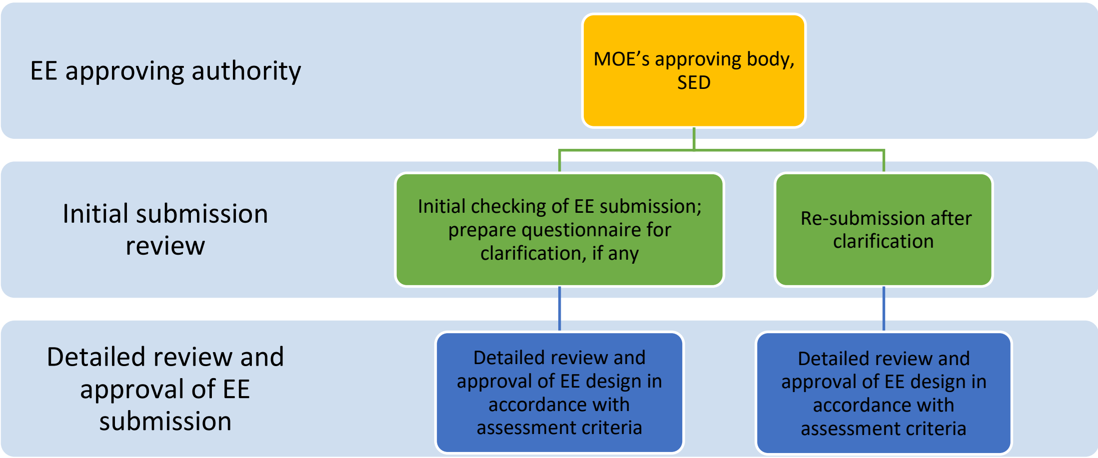
For designated buildings, as defined in Section 1.1.a), the developer or building owner shall include a section on EEC building design details. Such details confirm that the buildings were designed with EEC measures or features (including passive and active EEC measures) and suitable materials and energy management system (EMS) in their overall building plan submissions. (Refer to Section 4 of this report for EEC assessment and compliance requirements).

The person who designs this EEC building submission must be a qualified person who, together with other appropriate practitioners (i.e. mechanical and electrical professional engineers), will ensure that the minimum building energy performance and other EEC building requirements are met in their EEC building design submission. An example of the format for this section of the submission is in Appendix 3.

[1] Per the consultative meeting held in Brunei Darussalam in February 2020.

Figure 1.1 shows that the Sustainable Energy Department in the MOE is expected to review and approve the EEC building design submission under a sub-approval process to the existing overall building plan's approval process. The administrative aspect of this approval process is left to the relevant ministries and authorities to address and administer. Section 4 details the EEC assessment requirements.

Figure 1.1: Sub-approval Process for the Assessment of EEC Building Design Submission

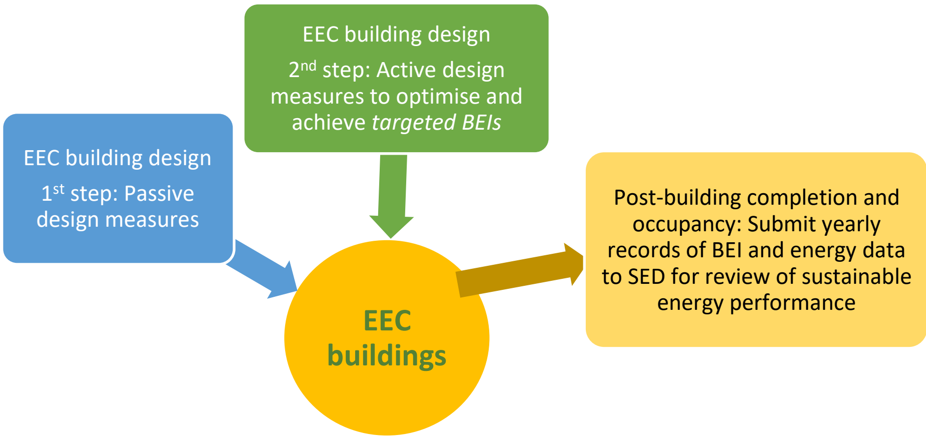


EE = energy efficiency, MOE = Ministry of Energy, SED = Sustainable Energy Department.
Source: Author.

1.3. Minimum and sustainable building energy performance requirements

The minimum building energy performance of a designated building shall have a level of energy performance that meets the requirements stipulated in the Piawai Brunei Darussalam (PBD) 12 EEC: 2015 Energy Efficiency & Conservation Building Guidelines. This EEC guideline for Temburong ecotown development complements the existing statutory requirements and policies. Figure 1.2 explains the concept of developing EEC buildings in Temburong district, which includes an action plan in the post-building completion and occupancy phase to ensure sustainable energy performance of designated buildings in Temburong district.

Figure 1.2: Guide for the Development of EEC Buildings in Temburong District



BEI = building energy intensity, EEC = energy efficiency and conservation, SED = Sustainable Energy Department.
Source: Author.

This EEC guideline provides the criteria for achieving minimum and sustainable building energy performance, as summarised below. For details of the passive design measures, refer to PBD 12 EEC:2015 Guidelines and MS1525:2019 (if updated information is required). These EEC requirements would form the basis for the assessment of EEC building design submission. Figure 1.7 shows the overall EEC assessment requirements and procedures, and Section 4 of this report discusses the details. The review criteria should comprise two main EEC design measures: passive and active design measures.

1.3.1. Passive Design Measures

a) Building envelope: façade design measures

Adequate façade design measures will ensure that the building envelope minimises heat gain into buildings via conduction and solar radiation. In a hot and humid climate, solar heat gain in air-conditioned buildings will substantially increase the cooling load. Therefore, minimising solar heat gain in a building is a critical consideration in designing an energy-efficient building. Such design consideration is based on the overall thermal transfer value (OTTV) concept computed for the façade design. Refer to PBD12 EEC:2015[2] and MS1525:2019 for further details.

The OTTV of the building envelope for a designated building must be 50 W/m^2 or less.[3] The OTTV shall apply to all external walls of the building and is computed by equations 1 and 2 below.

$$OTTV = \frac{(A1\ x\ OTTV1)+(A2\ x\ OTTV2)+\cdots+(An\ x\ OTTVn)}{A1+A2+\cdots+An} \qquad \text{--------- (1)}$$

where:

Ai = gross exterior wall area for orientation i
OTTV*i* = OTTV for orientation *i* from equation (2).

For a fenestration at any given orientation, the formula is given as follows:

$$OTTVi = 15\alpha\,(1 - WWR)Uw + 6(WWR)Uf + (194\ x\ OF\ x\ WWR\ x\ SC) \qquad \text{------- (2)}$$

where:

WWR = window-to-gross exterior wall area ratio for the orientation under consideration

α = solar absorptivity of the opaque wall
Uw = thermal transmittance of opaque wall (W/m^2 K)
Uf = thermal transmittance of the fenestration system (W/m^2 K)
OF = solar orientation factor

SC is the effective shading coefficient of the fenestration system, whereby solar heat gain coefficient (SHGC) = SC x 0.87.

[2] PBD12 EEC:2015 Energy Efficiency Building Guidelines 2015.

[3] Reference is made to PBD12 EEC:2015 Energy Efficiency Building Guidelines 2015, and MS1525:2019 Malaysian Standard, Energy Efficiency and Use of Renewable Energy for Non-residential Buildings.

b) Building envelope: roof design measures

There are two considerations in minimising heat gain through the roof. Firstly, the roof shall be designed to achieve a thermal transmittance (U-value) equal to or less than the value tabulated in Table 1.1.

Table 1.1: Maximum U-value for Roof (W/m^2 K)

Roof Type	Maximum U-value (W/m^2 K)
Lightweight (under 50 kg/m^3) (Non-concrete roof construction)	0.4
Heavyweight (above 50 kg/m^3) (Concrete roof construction)	0.6

Source: PBD12 EEC:2015.

In addition to the requirement in Table 1.1, the maximum recommended roof thermal transfer value (RTTV) for roofs with skylight is 25 W/m^2 or less. The concept of RTTV applies to an air-conditioned building where the roof is provided with skylight, and the entire enclosure is fully air-conditioned. The RTTV of the roof is given by equation 3 below.

$$RTTV = \frac{(Ar\ x\ Ur\ x\ TDeq)+(As\ x\ Us\ x\ \Delta T)+(As\ x\ SC\ x\ SF)}{A0} \quad \text{----------} \ (3)$$

where,

RTTV = roof thermal transfer value (W/m^2)
Ar = opaque roof area (m^2)
Ur = thermal transmittance of opaque roof area (W/m^2 K)
TDeq = equivalent temperature difference (K)
As = skylight area
Us = thermal transmittance of skylight area (W/m^2)
ΔT = temperature difference between exterior and interior design conditions
SC = shading coefficient of skylight
SF = solar factor
A_0 = gross roof area (m^2) where A_0 = Ar + As

1.3.2. Active Design Measures

Active design measures shall include the adoption of best practices in the design of energy-intensive systems. These include the selection of equipment and appliances that meet the minimum energy performance standard (MEPS). (Refer to Section 3 on MEPS for energy-intensive equipment.) Active design measures are summarised below. For further details, refer to PBD 12 EEC:2015 Guidelines and MS1525:2019 for updated information.

a) MEPS

As detailed in Section 3, MEPS is a specification containing several performance requirements for an energy-using device that prescribes a measurement of the energy performance of the device indicating its level of energy efficiency. MEPS can help the designer select devices or equipment to be incorporated into his design to achieve the desired level of energy efficiency.

b) *Building energy intensity (BEI)*

BEIs are energy efficiency indicators (EEIs) for the building sector. (Refer to Sections 2 and 4 for details.)

c) *Energy management system (EMS)*

The EMS, a subset of the building management system, provides a full complement of energy management features designed and programmed to control, monitor, and report energy consumption, intensities, and trending with tracking capability. (Refer to Section 1.4 for assessment requirements.) The records of BEIs and energy consumption data, including system loads, must be submitted to the Sustainable Energy Department yearly during the operation of designated buildings to monitor sustainable building energy performance.

In summary, Section 1.3 aims to ensure the achievement of minimum and sustainable energy performance in designated buildings by adopting a combination of passive and active design strategies, and by stipulating the requirements of continuous reporting and monitoring of BEIs during building operation (Figure 1.2) for sustainable building energy performance.

1.4. EEC legal framework

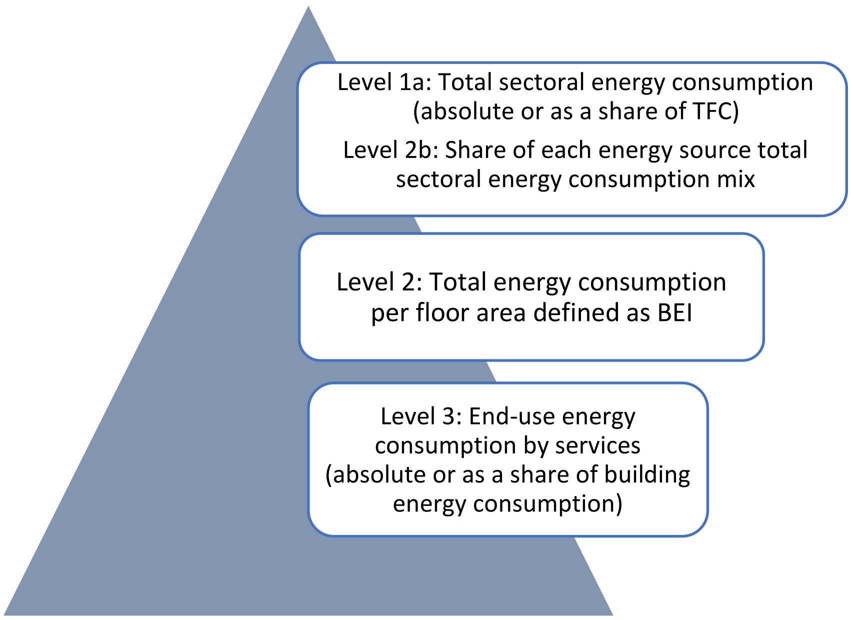
Implementation of the strategies and measures mapped out in this guideline on a voluntary basis would not be effective because it would likely be based on economic justification. Energy savings might not be sufficient to justify the investments in EEC installations due to the low tariff structure in Brunei Darussalam. This guideline provides practical EEC design measures and assessment of procedural process with review criteria as depicted in Figures 1.2**,** 1.7, and 1.8. However, this guideline will remain a reference document without a legal framework or regulatory requirements due to the lack of regulatory power for implementation in the commercial sector.

PBD 12 EEC:2015 Energy Efficiency & Conservation Building Guidelines was launched in May 2015 by the Minister of Development. These guidelines are mandatory for all government buildings but are voluntary only to all commercial buildings. Therefore, to make this Temburong EEC guideline effective, it is necessary to extend the existing mandatory requirements for government buildings to designated buildings in the commercial sector.

2. Labelling of BEIs

BEIs are energy efficiency indicators (EEIs). The concept of EEI is best explained by a pyramid of indicators of the International Energy Agency (IEA, 2014) (Figure 1.3). It explains the various levels of indicators and shows how indicators are organised into a hierarchy. The top of the pyramid in Figure 1.3 shows that the total energy consumption of the commercial sector or share of each energy source of the total commercial sector energy consumption mix is an aggregated indicator. IEA's concept of EEIs is a 'pyramidal approach' starting from the most aggregated level at level 1 to the most disaggregated level at end-use energy consumption by services, e.g. air-conditioning and mechanical ventilation, lighting, lifts and elevators, and escalators, etc. at level 3. The term BEI is used instead of EEI to differentiate the indicators from other sectors, such as the industry sector EEI, which has a different definition.

Figure 1.3: Pyramid of Commercial Sector Indicators



BEI = building energy intensity, TFC = total final consumption.
Source: Produced by the author based on IEA (2014).

2.1. Definition and applications

a) Definition

BEIs are a ratio of yearly energy consumption (measured in energy unit, kWh) to gross floor area (measured in square metre) under level 2 in Figure 1.3. For a meaningful comparison, the BEI values are to be compared with buildings within the same building subsector or category. In other words, the BEIs of office buildings, retail malls, hotels, hospitals, etc. should be compared within the same category or type of buildings because different building categories have different operating functions.

BEIs of buildings are computed at the subsector level and are calculated by the formula given in equation 4 below.[4] BEI is essentially a ratio of yearly energy consumption to gross floor area. However, to provide a more accurate representation of the energy intensity throughout the building, energy use in the car park area, which is usually not air-conditioned, and the data centre, where a high concentration of continuous energy use is expected, is excluded in the computation. Floor vacancy rate is considered only when the BEI is computed for an occupied building after the completion and occupancy of a building. For design submission, the building is usually considered fully occupied. The ratio of average weekly working hours to weighted weekly operating hours is used to make an adjustment to buildings that have different weekly operating hours compared with the national average weekly operating hours, such as office and retail buildings. This adjustment is to ensure a fair comparison of energy performance in different buildings of the same category.

$$BEI = \frac{(TBEC - CPEC - DCEC)}{(GFA - CPA - DCA) - (GLA\ x\ FVR)}\ x\ \frac{AWH}{WOH} \quad \text{----------- (4)}$$

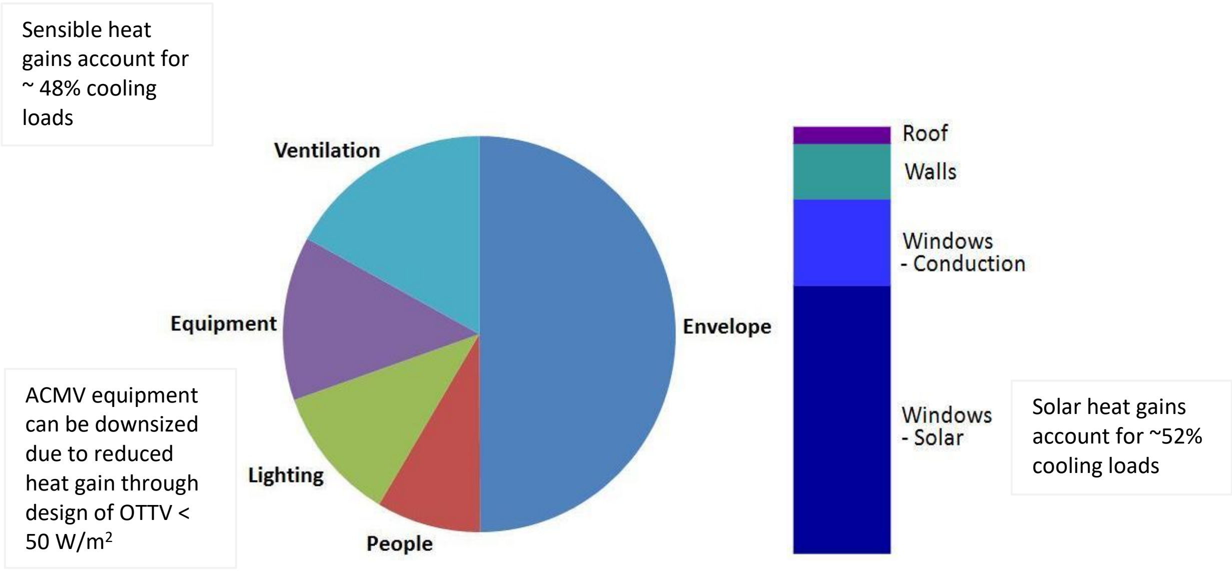
where:

TBEC	= total yearly building energy consumption (kWh/y)
CPEC	= yearly car park energy consumption (kWh/y)
DCEC	= data centre energy consumption (kWh/y)
GFA	= gross floor area (m^2)
CPA	= car park area (m^2)
DCA	= data centre area (m^2)
GLA	= gross lettable area (m^2)
FVR	= floor vacancy rate (%)
AWH	= average weekly operating hours (hours/week)
WHO	= weighted weekly operating hours (hours/week)

The majority share of energy consumption in commercial buildings in a hot and humid climate is energy use by air-conditioning and mechanical ventilation (ACMV) system required to provide thermal comfort in buildings. As reported in the Building Energy Technical Guideline for Passive Design (Public Works Department Malaysia, 2013), the typical energy breakdown in Malaysian office buildings is 50% for air-conditioning, 25% for electrical lighting, and 25% for small power (equipment). Figure 1.4 shows the ACMV system is required to remove solar thermal heat gains through the building envelope, which constitutes more than half of the cooling load. The ACMV system is also necessary to remove sensible heat gains from people, lighting, and other equipment in a building. Therefore, electricity consumption in commercial and public service buildings is energy use distributed throughout the floor areas. In other words, BEI, being total energy consumption over the gross floor area, indicates the efficiency of energy use in a building.

[4] Green Building Index Malaysia, www.greenbuildingindex.org.

Figure 1.4: Typical Breakdowns of Office Cooling Loads in Malaysia



Source: Author, adapted from the Danish International Development Agency study in Malaysia in 2005.

The establishment of the commercial sector EEI focuses on level 2 in the pyramid of commercial indicators. Level 2 focuses on the development of BEIs by building categories such as the following:

1) Office buildings
2) Hotels (one- to three-star rated, and four- to five-star rated)
3) Retail buildings or shopping malls (large, medium, and small)
4) Hospitals (large, medium, and small)

Each building subsector is expected to have different energy level intensities, mainly due to various building functions and operating hours. Hence, they will have different BEI benchmark values. The level of energy intensities in hotels is expected to be different for four- to five-star hotels. The services and amenities available in such hotels are more energy intensive than one- to three-star hotels. Therefore, the hotel category should be further classified under these two categories.

Similarly, retail buildings should be subdivided under low-end and high-end malls. Hospitals should be subdivided under large, medium, and small so that the BEI assessment can be made according to the respective building subsectors.

b) Applications

BEI labelling can be used as a tool to drive the agenda of energy efficiency in buildings. BEI labelling provides a means of measurement or indication of the energy performance of buildings in the same category. Optimising the energy efficiency in a building would involve a combination of passive and active design measures. This guideline is not intended to specify particular design measures because building design should be left to the building owners or developers and the building professionals' creativity to develop their innovative designs within budget allocations. However, BEI labelling can provide a guide with targets and indications of energy efficiency in buildings. The objectives of BEI labelling are summarised as follows:

1) To set minimum requirements of building energy performance for compliance by building owners, developers, and designers to ensure that designated buildings attain the required BEI labelling, which confirms the achievement of minimum energy performance;
2) To set minimum BEI target values for each commercial subsector or building category so that buildings are conscientiously incorporating EE design strategies to improve energy and environmental sustainability and meet the required standard of targeted energy intensity;
3) To be used as a guide and basis for the assessment of building energy performance by the EEC building approving authority;
4) To be used as a tool to recognise energy-efficient buildings, which will enhance the ecotown development of Temburong, and increase the market values of properties in the district.

2.2. Assessment of BEIs and BEI targets

As discussed in Section 2.1.b), BEI indicates energy efficiency in buildings. Various energy-efficient features or measures will be incorporated in a building design to achieve the BEI targets. Such design efforts and achievement of energy reduction are expected to culminate in lower BEI values. Therefore, building energy performance can be assessed by comparing and evaluating BEIs with pre-set BEI targets.

The establishment of BEI targets for various building categories usually requires historical data but such data are not readily available. Under such circumstances, the BEI targets listed in Table 1.2 are based on the entry-level BEI values for green buildings set by the Green Building Index (GBI) Malaysia and are suggested to be adopted as guide. The entry-level BEI values set by the GBI are the minimum requirement to qualify for one GBI point under the energy efficiency criterion. In other words, GBI entry-level BEI values set minimum requirements for EEC buildings. For office buildings in Brunei Darussalam, the minimum BEI required is 175 kWh/m^2. Table 1.2 provides a range of BEI target values from one-star to five-star ratings. The range of BEI target values is based on GBI Malaysia's range of GBI points scoring that begins with green building entry-level value. Table 1.2 shows that a one-star rating corresponds with the green building entry-level BEI. The highest five-star rating corresponds with a much lower BEI target value. Subject to the MOE's decision on the energy efficiency level for developing commercial buildings in Temburong district, the minimum BEI targets are suggested to be set at three-star rating to achieve recognition and acceptability as an ecotown. The concept of deriving the BEI target values was presented to the MOE and other government stakeholders during the second working meeting for Temburong Ecotown Phase 4 study in February 2020. The target values were generally accepted during the meeting.

Table 1.2 shows higher-star ratings, such as four- and five-star ratings, to encourage higher building energy performance, compared with three-star rating if this is chosen to be the minimum requirement for EEC buildings in Temburong. Such certified approval with star rating should clearly state that it is for the EEC building design submission. The actual BEI of a building may be different after the completion and occupancy of the building. Therefore, designated buildings in Temburong are required to submit yearly records of BEI values after building occupancy for the monitoring and compilation of energy statistics. This requirement is one reason Section 1.4 on the assessment and compliance method specifies the EMS provision under the step 3 assessment requirements. The EMS could track and keep records of building energy performance.

Table 1.2: BEI Targets for Commercial and Public Sector Buildings

Building Category	Average BEI Derived from Brunei Commercial Sector Survey	Green Building Entry Level for GBI [a] Malaysia BEI (kWh/m^2/y)	Suggested BEI Targets for Temburong (kWh/m^2/y)		Remarks
Office buildings	Small: 242 Medium: 227 Large: 275 Overall average: 258	150	5-Star: BEI ≤ 100 4-Star: 100 < BEI ≤ 120 3-Star: 120 < BEI ≤ 135 2-Star: 135 < BEI ≤ 150 1-Star: 150 < BEI ≤ 175		[b] Energy demand estimates based on 120 kWh/m^2/y
Retail buildings	Overall average: 308	[c] Low-end outlets: 240 [d] High-end outlets: 350	Low-end 5: 150 4: 180 3: 210 2: 225 1: 240	High-end 5: 250 4: 280 3: 310 2: 330 1: 350	Energy demand estimates based on 280 kWh/m^2/y
Hotels	1-3 Star: 177 4-5 Star: 371	3-star & below: 200 4-star & above: 290	≤ 3-star 5: 120 4: 150	≥ 4-star 5: 200 4: 230	Energy demand estimates based on 233 kWh/m^2/y

Building Category	Average BEI Derived from Brunei Commercial Sector Survey	Green Building Entry Level for GBI [a] Malaysia BEI (kWh/m^2/y)	Suggested BEI Targets for Temburong (kWh/m^2/y)		Remarks
			3: 175 2: 190 1: 200	3: 250 2: 270 1: 290	
Hospitals	Overall average: 334	Small-medium: 200 Large: 290	≤ medium 5: 120 4: 150 3: 175 2: 190 1: 200	Large 5: 200 4: 230 3: 250 2: 270 1: 290	Energy demand estimates based on 233 kWh/m^2/y
University	N/A	N/A	5-Star: BEI ≤ 100 4-Star: 100 < BEI ≤ 120 3-Star: 120 < BEI ≤ 135 2-Star: 135 < BEI ≤ 150 1-Star: 150 < BEI ≤ 175		Energy demand estimates based on 120 kWh/m^2/y
Industrial park	N/A	N/A	5-Star: BEI ≤ 100 4-Star: 100 < BEI ≤ 120 3-Star: 120 < BEI ≤ 135 2-Star: 135 < BEI ≤ 150 1-Star: 150 < BEI ≤ 175		Energy demand estimates based on 140 kWh/m^2/y

[a] Green Building Index Malaysia, www.greenbuildingindex.org/faq-green/#1582099483746-93d4e753-6907.
[b] The basis of energy demand estimates was adopted from Kimura (2017).
[c] Low-end outlets are retail outlets having low-energy intensity.
[d] High-end outlets are upmarket or large outlets having high energy intensity.
BEI = building energy intensity.
Source: Author, in consultation with the Sustainable Energy Department, Ministry of Energy.

3. Minimum Energy Performance Standard for Energy-Intensive Equipment

The MEPS specifies performance requirements for an energy-using device, effectively limiting the maximum amount of energy consumed by a product in performing a specified task. It provides details of specific minimum energy efficiency levels to the devices used. MEPS and labelling programmes for electrical appliances and equipment are widely recognised as a highly cost-effective energy efficiency policy measure. Hence, as part of the energy efficiency measures, MEPS and labelling programmes are recommended to be implemented in Temburong ecotown development.

A government energy efficiency body usually requires a MEPS to be either voluntary or mandatory. MEPS may include requirements not directly related to energy. This is to ensure that general performance and user satisfaction are not adversely affected by increasing energy efficiency. For Temburong ecotown development, MEPS is recommended to be mandatory for designated buildings. Besides contributing to achieving improved building energy performance, MEPS will ensure that the importation of electrical appliances and equipment would be regulated such that only appliances and equipment meeting the MEPS requirements are allowed to be imported and sold in Brunei Darussalam.

A MEPS generally requires the use of a particular test procedure specifying how performance is measured. With the MEPS in place, an energy labelling system will be established, and registration of the equipment will be done based on the labelling categories or rating system. This would set an energy benchmark to the appliances and equipment used and purchased by end users.

3.1. Implementation of MEPS

A few common criteria are observed and used in setting up MEPS. The criteria are summarised below and should be considered in preparing the standards:

1) *Scope*
   The standards proposed shall define the products that shall be included. Inclusion or exclusion of products could be based on the product type, power rating, or usage type.

2) *Normative standard*
   The standards set shall have normative reference criteria to refer to any existing performance or international standard – such as the International Electrotechnical Commission (IEC) and American Society of Heating, Refrigerating, and Air-Conditioning Engineers – and reference requirements for the condition, testing method, and performance.

3) *Terms and conditions*
   The specific terms and conditions shall be identified for the appliances. These include the following:

   a) The standards will also depict the parameters to be used to determine performance, such as
      - Fan : coefficient of performance
      - Refrigerator : energy efficiency factor

- Air conditioner : energy efficiency ratio; coefficient of performance; cooling seasonal performance factor (CSPF)
- Television : energy efficiency factor
- Lamp : efficacy

b) MEPS: the required minimum level of energy will be defined.
c) Star-rating requirements

With the MEPS requirements in place, a set of ratings and requirements to define the level of compliance of the energy performance would be established. The common method will be categorising them under star ratings such that the star ratings of one to five would correspond to the lowest to highest energy efficiency ratings. However, some appliances, such as lamps, do not require any star rating.

Another essential element of the MEPS and labelling programme is the testing standards and facilities available to carry out the appliance compliance tests, according to MEPS. Existing laboratory facilities in Brunei that could carry out the various tests to comply with the requirements were reviewed. We also examined the current international and regional laboratories to assist in conformance testing. No accredited testing laboratories exist in Brunei, only electrical product safety certification scheme by third-party testing. Since no certified testing laboratory is available in the country, it is recommended that Brunei jump-start the MEPS and labelling programme by collaborating with some regional test laboratories to carry out the tests accordingly. Or it can embark on a harmonisation programme such that the results of tests conforming to the MEPS requirements of one ASEAN member state may be accepted in Brunei, without having to undertake additional tests. Such a method can save time and resources required for the setting-up of testing procedures and facilities. Also, it would not hold up the implementation of EEC guidelines for designated buildings in Temburong district. Numerous internationally accredited test laboratories are available and registered under the ASEAN Secretariat. This is listed as Testing Laboratories and Certification Bodies under the ASEAN Sectoral Mutual Recognition Agreement for Electrical and Electronic Equipment. Whilst existing labs are available to implement MEPS and the labelling programme immediately, Brunei needs to establish a body that would manage the administrative, approving, and certification processes.

A wide range of electrical appliances and equipment are being used in the market for consumers and the commercial and industry sectors. Targeted appliances and equipment to be selected for labelling, such as lighting, refrigerator, air conditioners, fans, television, water heaters, motors, chiller, Others should be reviewed per their market demand, distribution, and their contributing shares of power consumption vis-à-vis the nation's final energy consumption.

For Temburong ecotown development, the selection of the targeted appliances and equipment is proposed to focus on intensive energy use and extensive equipment and appliance use as listed below.

3.2. Air-conditioning equipment

Air-conditioning equipment consumes the majority of electricity use in the residential and commercial sectors. Hence, it is essential to ensure that energy use in air-conditioning is efficient. There are two basic types of air conditioning equipment:

1) Unitary air-conditioning system

   In general, unitary air-conditioners are mainly used in the residential sector and in small commercial entities. Energy labelling for unitary air-conditioning equipment is based on a minimum performance criterion. One measurement used in MEPS for air-conditioning equipment is the cooling seasonal performance factor (CSPF). CSPF is the ratio of total annual amount of heat that the equipment can remove from indoor air when operated for cooling to the total annual amount of energy consumed by the equipment during the same period. Table 1.3 provides the unitary air conditioners minimum CSPF requirements as per Malaysian Standard MS:1515.

2) ACMV applied system

   The ACMV applied system is mainly installed in medium to large commercial buildings. It provides, in one or more factory-assembled packages, means for chilling water with controlled temperature for delivery to terminal units serving the conditioned space of the building. The chiller may be centrifugal, rotary, screw, scroll, or reciprocating, electrically driven type, absorption (heat-operated) type, or using other prime movers. The system also includes a system with a condensing unit, which receives its suction refrigerant vapour from a packaged or field assembled combination of cooling coil and fan and delivers the liquid refrigerant to the air-handling units. The electrically operated ACMV applied system performance rating value is suggested to be as per Table 1.4, which depicts the minimum energy performance requirement for chiller energy performance rating per Malaysian Standards 1515. The energy consumed by the external water pumps circulating the chilled water and the heat rejection device, such as cooling tower or heat exchanger, is not included in the coefficient of performance for the ACMV system component unless the manufacturer integrates the device into the package.

Table 1.3: Unitary Air Conditioners Minimum CSPF – Cooling Requirements

Equipment		Size	Minimum CSPF	
			Non-inverter type	Inverter type
Air-cooled condenser (or evaporative cooled)	<14.65 kWr	Single split	3.0	3.0
	≥ 14.65 kWr and <35 kWr	Split/Package/Multiple split (including VRF)	3.1	3.7
	≥ 35 kWr	Split/Package/Multiple split (including VRF)	3.0	3.2
Water-cooled condenser	<19 kWr	Split/Package/Multiple split (including VRF)	3.9	4.7
	≥ 19 kWr and <35 kWr	Split/Package/Multiple split (including VRF)	4.0	4.8
	≥ 35 kWr	Split/Package/Multiple split (including VRF)	4.1	4.9

CSPF = cooling seasonal performance factor, VRF = Variable Refrigerant Flow.
Source: MS1525:2019, Malaysian Standard.

Table 1.4: Water Chilling Packages, Electrically Driven: Chiller Energy Performance Rating

Equipment	Size	[a]COP at 100% Load at Malaysian Test Condition		[c]MPLV at Malaysian Standard Condition		[b]COP at 100% Load at Standard AHRI Test Conditions		IPLV at AHRI Standard Conditions	
		Min COP	Max kWe/RT	Min COP	Max kWe/RT	Min COP	Max kWe/RT	Min COP	Max kWe/RT
Air cooled, with condenser	< 105 kWr (30 RT)	2.93	1.20	3.36	1.05	2.93	1.20	3.84	0.92
	≥ 105 kWr and < 530 kWr (150 RT)	2.93	1.20	3.36	1.05	2.93	1.20	3.84	0.92
	≥ 530 kWr and < 1060 kWr (300 RT)	2.93	1.20	3.52	1.00	2.93	1.20	3.93	0.90
	≥ 1060 kWr (300 RT)	2.93	1.20	3.52	1.00	2.93	1.20	3.93	0.90
Water cooled, positive displacement (reciprocating, scroll, rotary, and screw)	< 260 kWr (75 RT)	4.56	0.77	4.35	0.81	4.74	0.74	5.86	0.60
	≥ 260 kWr and < 530 kWr (150 RT)	4.56	0.77	4.35	0.81	4.74	0.74	5.95	0.59
	≥ 530 kWr and < 1060 kWr (300 RT)	5.20	0.68	4.67	0.75	5.43	0.65	6.36	0.55
	≥ 1060 kWr (300 RT)	5.68	0.62	5.06	0.69	5.95	0.59	6.84	0.51

Water cooled, centrifugal	< 1060 kWr (300 RT)	5.60	0.63	5.27	0.67	5.86	0.60	6.15	0.57
	≥ 1060 kWr and < 2110 kWr (600 RT)	6.15	0.57	5.68	0.62	6.36	0.55	6.71	0.52
	≥ 2110 kWr (600 RT)	6.26	0.56	5.86	0.60	6.48	0.54	6.84	0.51

[a] Tested at Malaysian chilled water and condenser water temperatures.
[b] Tested at AHRI leaving chilled water temperature at 44^{0}F at 2.4 USGPM per tonne and entering water temperature of 85^{0}F at 3 USGPM per tonne.
[c] MPLV denotes Malaysia Part Load Value, which is a single-part load efficiency figure of merit calculated per method described in MS2449 at Malaysian Standard Rating Conditions, where for part-load entering condenser water temperatures (ECWT), the temperature should vary linearly from the selected ECWT at 100% load to 26.67^{0}C (80^{0}F) at 50% load and fixed at 26.67^{0}C for 50% to 0%.
AHRI = Air-conditioning, Heating, and Refrigeration Institute, COP = coefficient of performance , MPLV = Malaysia Part Load Value , IPLV = International Part Load Value.
Source: MS1525:2019, Malaysian Standard.

3.3. High-efficiency motors

Roughly 30 million new electric motors are sold yearly for industrial purposes; some 300 million motors are used in industry, infrastructure, and large buildings. The electric motors system includes controls such as contactor, soft-starters, variable speed drives, coupling accessories such as gear, belt and pulley, clutch and break, and the applications they drive such as pumps, conveyors, fans, and compressors. They are the single largest user of electricity, consuming more than 2.5 times as much as lighting. These electric motors are responsible for 40% of global electricity used to drive pumps, fans, compressors, and other mechanical traction equipment.

The technology of electric motors has also evolved tremendously in the last few decades. Through a selection of efficient motors, the efficiency of the motors will be improved compared to conventional motor systems. It is also notable that the country manufacturing them has also released numerous standards of electric motors.

Many different types of motors are being used globally. Three-phase a.c. induction motors constitute the large majority of motors over 0.75 kW sold worldwide. Therefore, MEPS and voluntary agreements worldwide have focused on this type of motor technology. Although smaller motors (below 0.75 kW or 1 HP) also present significant energy saving potential, they are mostly customised designs, generally incorporated into appliances and equipment, such as refrigerators, air conditioners, and air-handling units whose minimum efficiency performance can be regulated by addressing the whole appliance.

The International Electrotechnical Commission (IEC) has released a global-friendly standard on motors, IEC 60034: Rotating electrical machines. This standard of IEC classification intends to harmonise regional and national standards used in motors so far. This is a positive trend for motor users as it makes it much easier to compare efficiency levels between manufacturers and enables global customers to use the same motor designs.

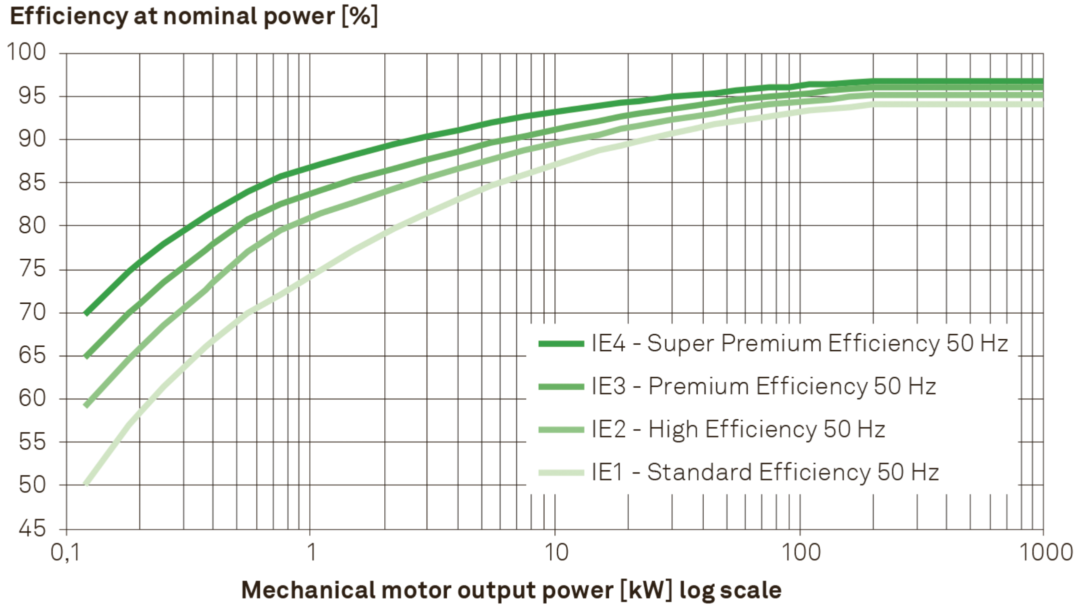
IEC 60034-1 states all the necessary rating plate information. Motors of the covered type always include a permanently attached durable nameplate. This nameplate includes the necessary information to install and operate the motor correctly. This information may consist of connections, horsepower or kW, design code, power supply, amps, and nominal motor efficiency expressed as a percentage of 100% at full load.

IEC 60034-2-1:2014 is published and defines the standard methods for determining losses and efficiencies from tests. This standard applies to d.c. machines and to a.c. synchronous and induction machines of all sizes within the scope of IEC 60034-1.

IEC 60034-30:2014 defines the efficiency classes for the motors. This IEC standard is concerned with the global harmonisation of energy efficiency classes for electric motors. The latest standard significantly expands the range of products covered with eight-pole motors and introduces IE4 efficiency performance class for electric motors. The standard defines four international efficiency (IE) classes for single-speed electric motors rated according to IEC 60034-1 or IEC 60079-0 (explosive atmospheres) and designed for operation on sinusoidal voltage. The four classes are (i) super-premium efficiency (IE4), (ii) premium efficiency (IE3), (iii) high efficiency (IE2), and (iv) standard efficiency (IE1).

Figure 1.5 shows a graphical presentation of this type of motor.

Figure 1.5: Efficiency (%) vs Mechanical Motor Output Power (KW) as per IEC 60034-30:2014 Classes



Source: IEC 60034-30:2014.

The new standard covers a broader scope of products. The power range has been expanded to cover motors from 120 W to 1,000 kW. All technical constructions of electric motors are covered as long as they are rated for direct online operation. The coverage of the new standard includes the following:

- Single-speed electric motors (single- and three-phase power supply), 50 and 60 Hz;
- Two, four, six, or eight poles;
- Rated output nominal power from 0.12 kW to 1,000 kW;
- Rated voltage nominal voltage above 50 V up to 1 kV;
- Motors capable of continuous operation at their rated power with a temperature rise within the specified insulation temperature class;
- Motors marked with any ambient temperature within the range of -20 °C to +60 °C; and
- Motors marked with an altitude up to 4,000 m above sea level.

The following motors are excluded from IEC 60034-30-1:

- Single-speed motors with 10 or more poles or multi-speed motors;
- Motors completely integrated into a machine (for example, pump, fan, or compressor) that cannot be tested separately from the machine; and
- Brake motors when the brake cannot be dismantled or separately fed.

However, most of the national MEPS only apply to general purpose motors. This is because motor efficiency is sometimes compromised by design restrictions imposed by special working requirements, such as motor specifically designed for special requirements of the driven machine like heavy starting duty, special torque stiffness and/or breakdown torque characteristics, large number of start and stop cycles, and very low rotor inertia.

All motors shall be tested according to IEC 60034-2-1:2014 or IEEE 112:2004.

Test reports from the following laboratories are accepted:

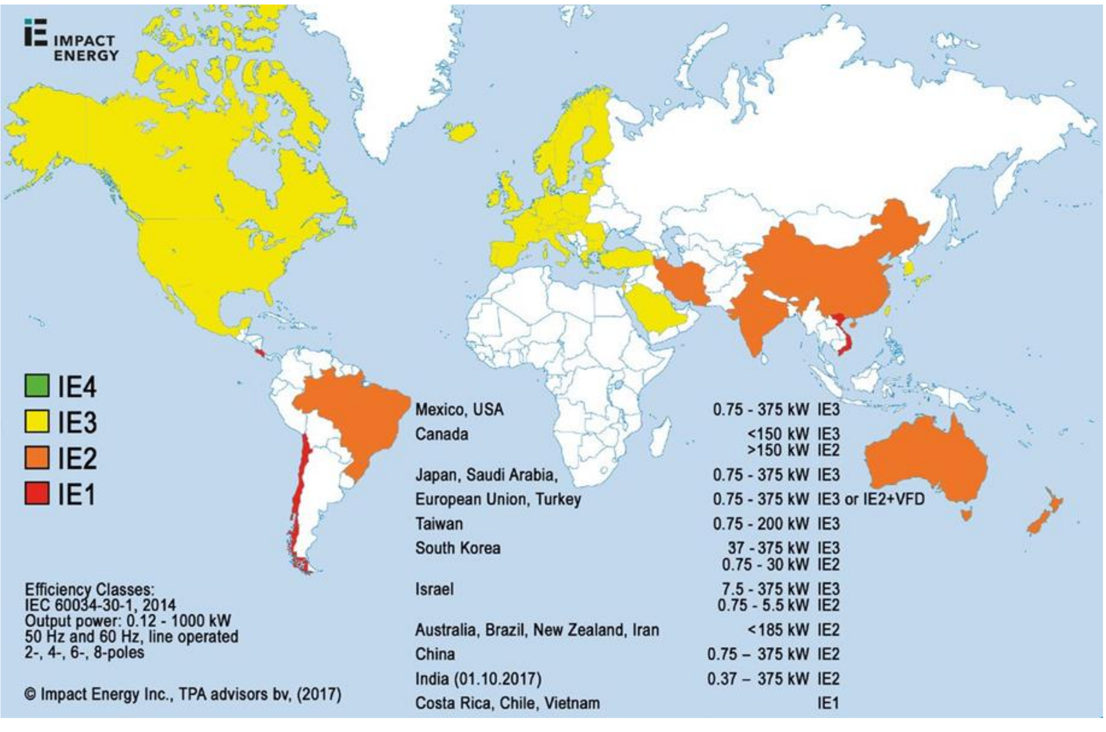
1) manufacturers' in-house test laboratories, and
2) test laboratories that have been accredited to carry out the test under the applicable test.

The demand and awareness of the high-energy efficiency motors are still at the infant stage. A study by Impact Energy Group 2017 showed that a small portion of the countries have made motors achieving IE2 and above standards mandatory. In general, most countries have not adopted the IEC efficiency classes as a benchmark for motors. Figure 1.6 depicts the overall global IEC efficiency classes in relation to the IEC efficiency classes.

Some concerns in implementing the minimum energy performance requirement for motors are listed below:

1) Currently, most of the motors used in the market are IE 1 motors.
2) Most of the installed motors are in operation for more than 15 years.
3) Operators are not concerned with motor efficiency and life cycle costs.

Figure 1.6: Global MEPS Mapping Based on Classification of IEC IE Efficiency



IE = internal efficiency.
Source: UNEP (2017).

3.4. Lighting

As outlined in Appendix 1: Fundamentals of Energy Efficiency in Buildings, the share of lighting energy in an office building could be as much as 27%, which is the second-largest proportion of energy consumption besides the ACMV system. Therefore, it is prudent to prioritise lighting to be listed in the MEPS and labelling programme.

Selection of inefficient light fittings and inefficient lighting design will cause unnecessary higher lighting power. It will also increase the cooling load because higher lighting energy will end up as heat in buildings. In other words, the ACMV capacity will need to be increased due to the increased cooling load. This will result in higher equipment and operating costs due to the higher air-conditioning load.

Luminous efficacy is an indicator of the efficiency of lamps. The higher efficacy values indicate higher efficiency, producing more light for the same energy used. It is defined as:

$$Efficacy = \frac{Lumen}{Watt}$$

Hence, the MEPS commonly used will be the measured efficacy of the lamp in lumen/watt, which shall be determined under the relevant standards set. Table 1.5 outlines the efficacy of various types of lamps in the Malaysian Standard; MS 2598:2014 Minimum Energy Performance Standards for Lamps.

3.5. Summary of MEPS

Given the advancement of product technology and more vigorous energy-saving initiatives globally, MEPS and labelling programme are evolving product requirements. Therefore, its periodic review is imperative to ensure the programme keeps up with advances in technology. As a result, new or revised MEPS or labelling requirements may be introduced, especially for regulated products, from time to time. Also, subject to the development of energy-efficient products, MEPS and labelling requirements should be reviewed and updated from time to time for new products and improved energy performance of products.

It is recommended that the MOE embark on a harmonisation programme to expedite the implementation of MEPS and the labelling programme to be ready for the adoption of EEC guidelines in Temburong ecotown development. The programme is based on selected member state/s in the ASEAN region, without setting up testing facilities soon. However, for long-term planning, Brunei Darussalam may want to consider setting up testing facilities. Nevertheless, for Temburong development, the adoption of MEPS should become a mandatory requirement for designated buildings in selecting appliances and equipment, which are listed in the MEPS and labelling programme.

Table 1.5: Minimum Efficacy (lm/w) for Various Types of Lamps and Ratings

Type of Lamp	**Self-ballasted Single-capped Lamps [Compact Fluorescent Lamps (CFL)] for General Lighting Services**
Lamp rating (W)	**Minimum efficacy (lm/W)**
< 9	46
≥ 9 to < 15	52
≥ 15 to < 25	55
≥ 25	62
Type of Lamp	**Single-capped fluorescent lamps (non-integrated compact fluorescent lamps) and circular fluorescent lamps for general lighting services**
Lamp rating (W)	**Minimum efficacy (lm/W)**
< 10	46
≥ 10 to < 19	55
≥ 19 to < 52	59
≥ 27	70
Type of Lamp	**Self-ballasted Light Emitting Diode (LED) lamps for general lighting services**
Lamp cap type (as in MS IEC 60061-1)	**Minimum efficacy (lm/W)**
G13	75
GU10	50
E27 or B22d	60
E14	60

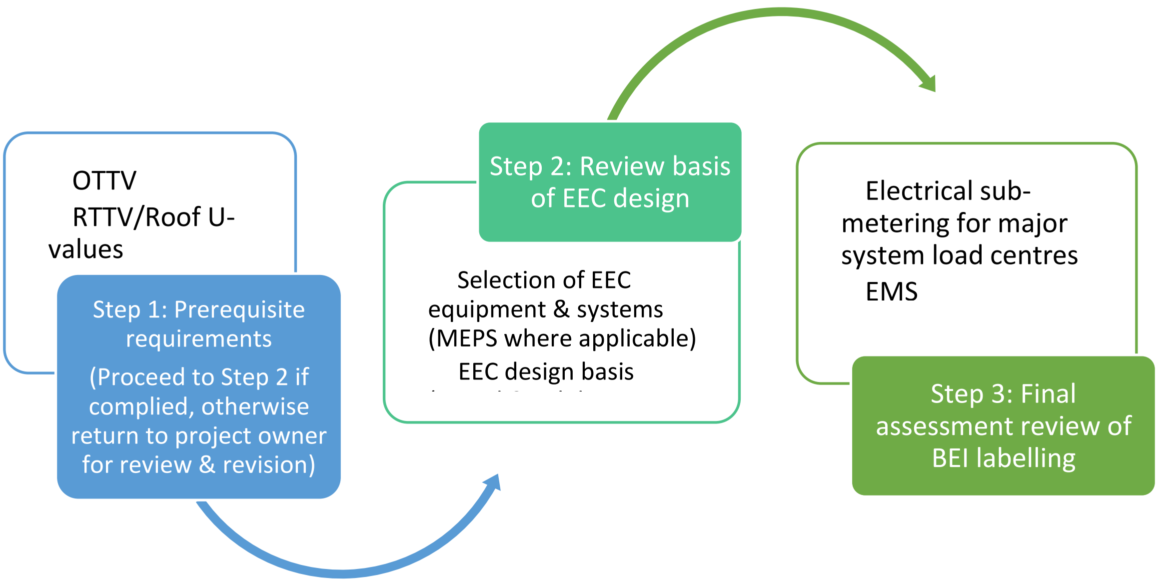
Source: MS 2598:2014.

4. Assessment and Compliance Method

The achievement of energy-efficient buildings does not just rely on one EEC measure or method but on a combination of passive and active EEC design measures, as highlighted in Section 1.3 and Appendices 1 and 2. Passive design measures must be incorporated first before the active systems in a building are designed (Figure 1.2). Accordingly, the EEC section of the building development (or EEC building design) submission should be first assessed for compliance with the passive design requirements, which are minimum EE performance, before assessing other aspects of EEC building design. Hence, basic passive design measures are prerequisite requirements (Figure 1.7).

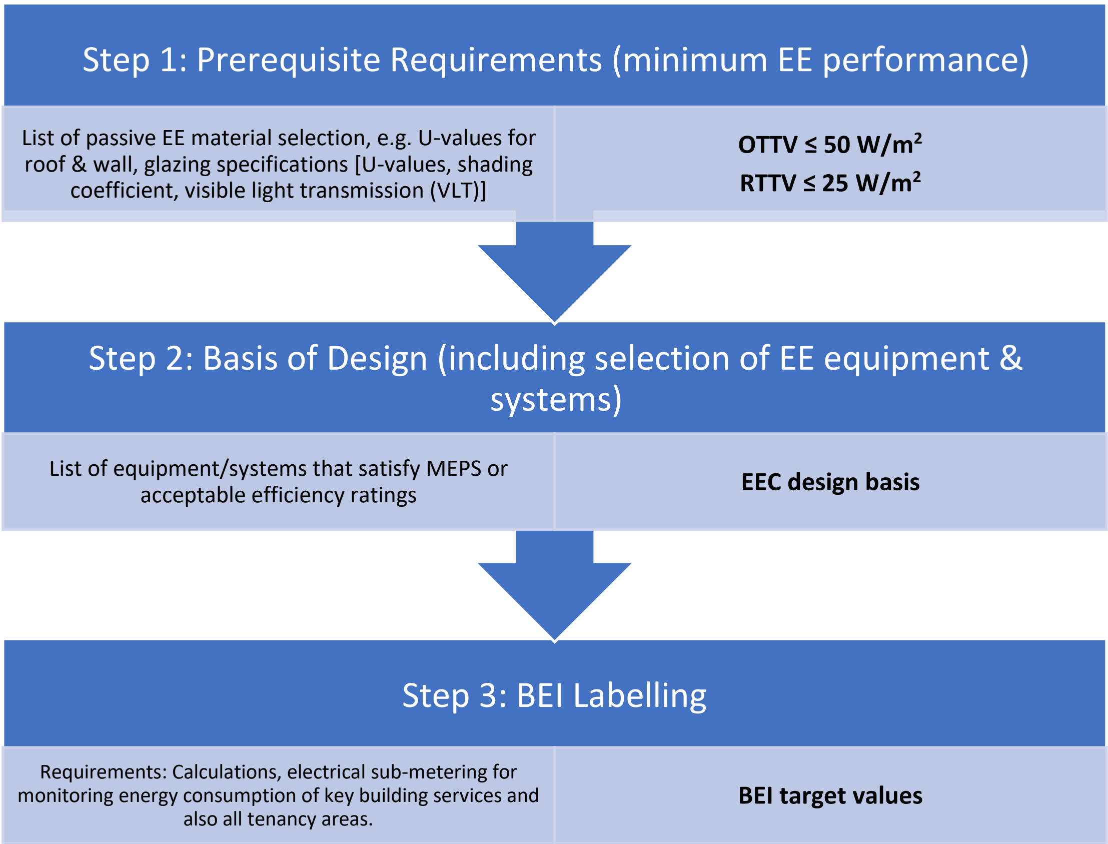
The EEC building design submission should be assessed for compliance in three areas: (i) passive design requirements, (ii) basis of design (BoD) (which includes a selection of equipment/system based on MEPS), and (iii) BEI labelling comprising target values. The basis and sequence of assessment are summarised in Figure 1.8, which shows the steps and methodology to be used as an EEC building design approval procedure. Therefore, Figures 1.7 and 1.8 show the flow of EEC building assessment activities. This aspect of the guideline on the assessment and compliance method is recommended to the MOE for review and adoption in establishing EEC buildings in Temburong.

Figure 1.7: Overview of Procedures for EEC Building Design Assessment



BEI = building energy intensity, EEC = energy efficiency and conservation, EMS = energy management system, OTTV = overall thermal transfer value, RTTV = roof thermal transfer value
Source: Author.

Figure 1.8: EEC Building Design Assessment Criteria and Flowchart



BEI = building energy intensity, EE = energy efficiency, EEC = energy efficiency and conservation, MEPS = minimum energy performance standard.
Source: Author.

Figure 1.8 shows the three steps of EEC building design assessment: (i) prerequisite requirements, (ii) BoD, and (iii) BEI labelling checks. The intents of these assessment steps are explained as follows:

1) Step 1: Prerequisite requirements

- The prerequisite requirements intend to establish the minimum energy performance, which is the first step in establishing the EEC building design. Meeting the prerequisite requirements is mandatory (refer to Table 1.6 for details of compliance checks). Therefore, further assessment of the EEC design submission will not proceed if these requirements are not satisfied, i.e. such submission will need to be queried, clarified or reviewed, revised, and resubmitted if the initial submission failed to meet the requirements.

2) Step 2: Basis of design (BoD)

- The BoD aims to ensure that building designers are knowledgeable on EEC design and have paid attention to sound BoD on EEC design criteria (refer to Section 4.2 for details).
- Step 2 will allow the assessment team to examine the basis of EEC design, which includes selecting appliances, equipment, and systems following the MEPS, where

applicable. Building designers must also declare other BoDs in EEC building design submission, as detailed in Section 4.2. This is an essential step of the assessment because information on BoD will provide bases or clues for the eventual compliance of the step 3 assessment on BEI labelling. For example, if BEI calculation shows good BEI value but the information given in the BoD does not correlate with the BEI calculation, more detailed checks and queries, including clarifications, will need to be carried out.

3) Step 3: BEI labelling

- BEI labelling intends to ensure that the energy efficiency performance of designated buildings in Temburong exceeds the SED's baseline BEI values.
- The step 3 assessment is the final EEC building assessment step, a design assessment based on the design estimation of BEI values. It does not cover the completion and verification assessment upon building completion and occupancy.
- The records of BEI values are recommended to be submitted to SED yearly during the designated buildings' operation for subsequent monitoring purposes to ensure sustainability in building energy performance of designated buildings.

4.1. Minimum energy efficiency performance

Minimum energy efficiency performance is recommended to be the prerequisite requirements before any further assessment is made. The minimum EE performance requirements are based on the details given in Section 3.1. Assessment is made based on building envelope calculations on the criteria listed in Table 1.6.

Table 1.6: Prerequisite Energy Efficiency Performance Requirements

	Prerequisite Requirements	Remarks
Overall Thermal Transfer Value (OTTV)	OTTV ≤ 50 W/m^2	Calculations based on PBD 12 EEC:2015 Energy Efficiency & Conservation Building Guidelines Plans and elevations marking out walls and apertures used for the calculation to be in blue; walls and apertures not used for the calculation to be in red. Preferred scale of plans: 1:200.
Roof Thermal Transfer Value (RTTV)	RTTV ≤ 25 W/m^2 (Applicable if building roof is provided with skylight and the entire enclosure below is fully air-conditioned, e.g. atrium.)	Calculations based on PBD 12 EEC:2015 Energy Efficiency & Conservation Building Guidelines
Maximum U-value for roof	Lightweight (Non-concrete roof construction): ≤ 04(W/m^2 K) Heavyweight (concrete roof construction): ≤ 0.6 (W/m^2 K)	The roof shall not have a thermal transmittance (U-value) greater than these values.

Source: MS1525:2019, PBD12 EEC:2015.

4.2. Basis of design (BoD)

Information based on EEC building design, including the selection of appliances, equipment, and systems in compliance with MEPS, where applicable, is required to be included in the EEC building design submission for assessment purposes. This is one way of ensuring that the sound basis of EEC building design is adopted in the design of designated buildings in Temburong. By providing such information, the SED assessment team has another avenue to review the extent of EEC design considerations that allow the BEI baseline values to be achieved.

4.2.1. Selection of Energy Efficiency Equipment and Systems

In addition to the air-conditioning system (in terms of high coefficient of performance or low kW/RT), the use of other electrical appliances and equipment, collectively referred to as plug load, should not be overlooked as both contribute significantly to energy consumption in buildings. Where applicable, appliances and equipment meeting the MEPS requirements are recommended to be used. The use of energy-efficient plug load equipment provides twofold benefits. Firstly, energy-efficient plug load equipment consumes less electricity. Secondly, equipment consuming less energy will produce less heat in a space, which means that such equipment will help reduce the cooling load in the building. Therefore, the selection of energy-efficient equipment and systems can be taken as helping achieve the BEI target in EEC building design. The review of the plug load equipment should be based on the guidelines in MEPS, where available; otherwise, MEPS from other countries may be used for reference. In general, equipment and systems having energy efficiency ratings should be used.

4.2.2. EEC BoD

Other contributing factors towards reducing energy consumption and lowering BEI values are avoiding overdesign in areas such as lighting, air-conditioning and mechanical ventilation, temperature control, electric power and distribution, lifts, and escalators. The objective of EEC BoD is to ensure that the design computation of BEIs for the step 3 assessment is based on sound and valid EEC criteria. For the details of design criteria of various services, refer to PBD 12 EEC:2015 Guidelines (or MS1525:2019 for updated reference). Therefore, for assessment purposes, EEC building design submission must provide information on BoD concerning EEC. The following are examples of EEC BoD.

a) Lighting[5]

– Specify average illuminance levels in design, examples:
  - o Lighting for infrequently used area
    - ▪ Interior walkways and car parks: 100 Lux
    - ▪ Hotel bedrooms: 100 Lux
    - ▪ Corridors, passageways, stairs: 100 Lux
  - o Lighting for working interiors
    - ▪ General offices, shops and stores, and writing: 300–400 Lux
    - ▪ Restrooms, bathrooms: 150 Lux

[5] PBD 12 EEC:2015 Energy Efficiency & Conservation Building Guidelines (& MS1525:2019 for updated reference).

- Restaurants, canteens, cafeterias: 200 Lux
- Shops/supermarkets/department stores: 200–750 Lux
- Classrooms, libraries: 300–500 Lux

– Interior building lighting power density, examples are given in Table 1.7.

Table 1.7: Interior Lighting Power Density (including Ballast Loss) Allowance for Typical Building Area

Type of Usage	Maximum Lighting Power Density (W/m^2)
a) Lighting for infrequently used areas:	
– Minimum service illuminance	3
– Interiors	5
– Lift interiors	5
– Corridors, passageways, stairs	5
– Escalators, travellators	6
– Entrance halls, lobbies, waiting rooms	5
– Inquiry desks	11
– Guard houses	8
b) Lighting for working interiors	
– Infrequent reading and writing	8
– General offices, shops and stores, reading and writing	12
– Restrooms	6
– Restaurants, canteens, cafeterias	8
– Kitchens	11
– Lounges	6
– Bathrooms	6
– Toilets	5
– Bedrooms	5
– Classrooms, libraries, reading areas	15
– Retail stores	24
– Museums and galleries	11
– Proofreading	18

Source: MS1525:2019.

Table 1.8: Maximum Lighting Power Intensity Allowance of Building Exteriors

Building Exteriors	Maximum Lighting Power Intensity
Uncovered parking areas	2
Uncovered driveways	2
Pedestrian malls	5
Landscape areas	5

Source: MS1525:2019.

b) *Air-conditioning hydronic system*

– In addition to selecting energy-efficient chillers for chilled water system, it is important to design the water pumping system with a system power exceeding 7.5 kW and operating for more than 750 hours a year, following the system efficiency listed in Table 1.9. For further design details, refer to MS1525:2019.

Table 1.9: Maximum Power Consumption for Pumping System

Type of Pumping System	Maximum Power Consumption [W/(m³/h)]
Condenser water pump	84
Chilled water pump	97

Source: MS1525:2019.

4.3. BEI labelling

BEI labelling, assessment step 3, is the final step in the EEC building assessment. It evaluates building energy performance based on the design for designated buildings in Temburong with respect to the baseline BEI values set by SED. Reference values are shown in Table 1.2. BEI values would be evaluated according to the target values of the same building subsector or building category. In other words, the BEIs of office buildings, retail malls, hotels, hospitals, etc. are compared with the respective target value of the same category or type of building.

Although the assessment is based on BEI calculations in EEC building design submission, it is necessary to ensure that the design includes facilities that will monitor and verify information or data to confirm the BEI performance. This will also help the building owner/operator continuously review and monitor the building's sustainable energy performance. Thus, the following facilities should be included in the design:

a) Electrical sub-metering to provide electricity consumption data for main load centres or significant energy users such as the air-conditioning system including auxiliary equipment like cooling towers, pumps, air-handling units, fan coil units, lighting, lifts and escalators, major water pumping system, plug loads, and any additional item whose energy use ≥ 100 kVA

b) Building energy management system (BEMS)
   1. BEMS requirements shall comply with PBD12 EEC:2015, Brunei.
   2. Up-to-date BEI information and BEI trending graphs to show historical average monthly BEI values for tracking and reporting, which can be used for analysis and energy audit purposes.
   3. The average BEI value computation is required to consider building occupancy rates and operating hours.
   4. BEMS software that monitors energy should be able to do real-time reporting and can compare data against historical data.

Table 1.10 shows the checklist for step 3 assessment.

Table 1.10: Checklist for Step 3 Assessment of EEC Building Design Submission

Assessment Item	Requirements	Remarks
1. Major load centre sub-metering	To check electrical sub-metering load centres: a. Air-conditioning systems incl. auxiliaries b. Lighting c. Lifts and escalators d. Major water pumping systems e. Plug loads f. Tenancy areas, if applicable g. Others (to specify)	To check sub-metering compliance
2. BEMS	To check the provision of BEMS functions: a. Compliance with PBD12 EEC:2015, Brunei b. Computation and monitoring of BEI with tracking and reporting capability for analysis and energy audit purposes.	BEMS will facilitate continuous EEC building operations. Building management and/or owners must submit yearly records of BEI values after building occupancy to monitor and compile energy statistics.
3. BEI labelling	Computed BEI value: a. BEI value to be declared b. BEI calculations to be included	Design BEI value to comply with the target value listed in Table 2.1. If this final item complies with Table 2.1 besides complying with items 1 and 2 of this table, and the requirements in Sections 4.2.1 and 4.2.2 are met after complying with 4.1, the EEC design will be approved.

BEI = building energy intensity, BEMS = building energy management system, EEC = energy efficiency and conservation.
Source: Author.

5. Conclusions

The anticipated Temburong development will offer Bruneians an opportunity to incorporate energy efficiency in developing an ecotown. This opportunity, if seized early and coordinated well, can be translated into several benefits, such as energy and environmental sustainability of an ecotown, showcase of efficient demand-side management in the commercial sector, showcase of greenhouse gas (GHG) reduction, and promotion of ecotourism. If proven successful, the EEC strategies and measures mapped out in this guideline can be implemented for nationwide adoption of EEC practices, contributing to Brunei's energy and environmental sustainability goals. However, the successful implementation of EEC strategies and measures recommended in this guideline will depend on whether the existing regulatory requirements are adequate or whether specific EEC regulations will be introduced. This is because implementation on a voluntary basis would not be effective.

This guideline is intended to assist the MOE, Brunei Darussalam in formulating a plan and a guide for incorporating EEC measures in developing Temburong ecotown. This guideline aims to establish the requirements for EEC practices, minimum building energy performance, and assessment procedure and criteria for the approval of EEC building design submission, which is part of the overall building development plan submission aimed at developing the Temburong ecotown.

This guideline refers to PBD 12 EEC:2015 and MS1525:2019, the established design reference guidelines and standards. The similarities between these documents and this Temburong EEC guideline are the passive and active design methods and measures. However, this guideline focuses on methodology to map out an EEC assessment procedure (complete with compliance criteria), which comprises three steps (as detailed in Section 4) as follows:

Step 1: Prerequisite requirements (mandatory passive design compliance)
Step 2: BoD (including MEPS and other EEC active design bases)
Step 3: BEI labelling (to determine whether the EEC building design submission meets the requirements that include incorporation of BEMS and BEI compliance)

The assessment procedure mentioned provides an avenue for SED to check the steps and basis taken by building designers in their EEC design submissions. As a measure of ensuring sustainability in building energy performance, this guideline recommends that designated premises submit their annual building energy consumption reports, which include actual BEI values recorded in BEMS for continual tracking and verification purposes.